
***Deepwater Horizon* Natural Resource Damage Assessment:
Quantifying Potential Exposures of Birds to
Deepwater Horizon Oil in Louisiana Coastal Marsh Habitats**
Technical Report
Draft

Prepared for:

State of Louisiana
Coastal Protection and Restoration Authority
PO Box 44027
Baton Rouge, LA 70804

Prepared by:

Bryan Wallace
Kaylene Ritter
Abt Associates Inc.
1881 Ninth Street, Suite 201
Boulder, CO 80302
303-381-8000

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1. Introduction and Summary

This report describes an approach to quantifying the potential exposure of birds to *Deepwater Horizon* oil in Louisiana coastal marsh habitats. The exposure to oil and the consequential injury to birds in Louisiana coastal marsh habitats have been identified as sources of uncertainty in efforts to quantify avian mortalities (IEc, 2015). By providing estimates of the number of marsh birds potentially exposed to oil, we provide some perspective on the potential for this type of avian injury that is supplemental to the modeled injury calculations identified in the Programmatic Damage Assessment and Restoration Plan (PDARP).

To quantify potential avian exposures in marsh habitats, we used available information on average densities of four illustrative species of Louisiana coastal marsh birds, together with information on the linear extent of oiling along Louisiana mainland herbaceous marsh edge habitat (Wobus et al., 2015). Using this approach, we estimated that approximately 19,000 birds of the four representative species were potentially exposed in heavily oiled shorelines, and that another 37,000 individuals of these four species were potentially exposed to less heavily oiled marsh habitats.

Although we estimated that some 56,000 birds of the four exemplar species were present in oiled marsh habitats, at this time we have not quantified the degree and extent of injury. The actual proportion of the birds present that came into contact with oil, and the extent of oil exposure, are uncertain because they were not actually measured due to difficulties sampling in dense marsh habitats (IEc, 2015). Consequently, quantification of the ultimate fate of oiled birds was not undertaken. However, some proportion of the birds present in oiled marsh were, in fact, exposed to oil. Further, some proportion of those oiled birds were injured. Therefore, exposure of marsh birds to oil in Louisiana marsh habitats represents a largely unquantified avian injury. Habitat restoration in complex coastal marsh habitats such as those that were oiled would be best to compensate for losses of these marsh-dependent species.

The remainder of this report is structured as follows: Section 2 provides background on the importance of Louisiana coastal marsh habitats for birds and discusses the context for this analysis. Section 3 presents a description of methods used in the analysis. Results are presented in Section 4, and Section 5 contains a discussion of our results, including other sources of information that lead to the conclusion that marsh birds were injured, as well as a discussion of how assumptions in our analysis could have influenced our results.

2. Description of the Resource and Context for Analysis

Nearly half of the northern Gulf of Mexico shoreline that was oiled occurred in marsh habitats, and approximately 95% of the oiled marsh was in Louisiana (Michel et al., 2013). Furthermore, these marsh habitats were exposed repeatedly to oil as it washed ashore. Oil penetrated into marsh habitats in many areas that were not surveyed or where oil was not detected by shoreline cleanup and assessment technique (SCAT) teams (DWH Trustees, 2015, Section 4.6). More than two-thirds of all the birds that were recovered dead during spill response activities were found in Louisiana marshes – including several species that typically occupy only interior areas of coastal marsh habitats and are difficult to find [e.g., Clapper Rails (*Rallus crepitans*), Least Bitterns (*Ixobrychus exilis*)] (IEc, 2015).

The Louisiana marsh habitats that were exposed to oil represent one of the largest expanses of saltwater, brackish, and freshwater marshes anywhere in the world. This rich and expansive habitat supports abundances of bird species, representing waterbirds, migratory passerines, raptors, and many others, that are among the highest in North America (Remsen et al., 2015).

Two species that are well-documented specialists of coastal marsh habitats are Clapper Rails and Seaside Sparrows (*Ammodramus maritimus*). These birds were particularly vulnerable to exposure in oiled marshes because they primarily inhabit saline marsh-edge habitats (Remsen et al., 2015) – habitats that suffered extensive oiling. Louisiana marshes, in particular, are thought to host the world's largest populations of these two species, as well as numerous other species that use these habitats for some or nearly all of their lives, including Mottled Ducks, Least Bitterns, Green Herons, Common Gallinules, Willets, Pied-billed Grebes, Marsh Wrens, Orchard Orioles, Common Yellowthroats, Boat-tailed Grackles, and Red-winged Blackbirds (Remsen et al., 2015).

As described in the PDARP, the Trustees quantified avian mortalities using a quantitative extrapolation from the number of dead and live-impaired birds recovered on beaches and marsh edges, as well as observations of live oiled birds in coastal habitats in 2010 and 2011 (IEc, 2015). One aspect which was not quantified was the injury and potential mortality to interior marsh birds. Given the uncertainties associated with interior marsh bird injury, we undertook an evaluation of the potential exposure of marsh birds to *Deepwater Horizon* oil to provide context for understanding the potential scope of injury to this natural resource.

To address this uncertainty, we undertook an evaluation of the potential exposure of marsh birds to *Deepwater Horizon* oil to provide context for understanding the potential scope of injury to this natural resource.

3. Methods

For this analysis, we focused on four marsh bird species in Louisiana for which there were available density data: Seaside Sparrows, Clapper Rails, Least Bitterns, and Red-winged Blackbirds (*Agelaius phoeniceus*).

First, we assembled data on densities of the four marsh bird species listed above. These data were collected and densities estimated during a Natural Resource Damage Assessment (NRDA) study in June and July 2010 that used passive sighting and acoustic identification surveys in different marsh habitats (e.g., *Spartina*-dominated and *Phragmites*-dominated) (Conroy, 2013). Although Conroy (2013) estimated densities using multiple methods, we used only density values derived from distance sampling models because these models had fewer assumptions and generally performed better than other modeling approaches (Conroy, 2013). Bird densities ranged between 0.05 individuals per hectare (Least Bitterns in *Spartina* marsh) to 3.4 individuals per hectare (Seaside Sparrows in *Spartina* marsh) (Table 1).

Table 1. Density estimates for four marsh bird species based on surveys in *Spartina* and *Phragmites* marshes in Louisiana

Species	Density (# individuals / hectare)			
	<i>Spartina</i>		<i>Phragmites</i>	
	Mean	95% CI	Mean	95% CI
Seaside Sparrow	3.38	2.63–4.26	0.71	0.56–0.89
Clapper Rail	1.51	1.22–1.85	0.30	0.11–0.86
Least Bittern	0.05	0.02–0.20	0.94	0.48–1.81
Red-winged Blackbird	0.67	0.48–0.93	1.65	1.13–2.40
CI: confidence interval.				
Source: Conroy, 2013.				

Next, in order to estimate the number of individual birds present in oiled marsh habitat, we assumed that bird densities, which were available as numbers of individuals per hectare (1 hectare = 100 m x 100 m, or 1,000 m²; Conroy, 2013), represented conceptual “territories” of size equal to 1 hectare each. In biological terms, a breeding territory defines the area within which an animal acquires required ecological resources (e.g., mates, food, shelter) and spends nearly all of its time during the spring/summer breeding season, and are non-uniformly distributed and shaped. However, in this case, we used standardized 1-hectare “territories” only as a simplifying assumption to allow multiplication of densities (birds per unit area) by oiled shoreline (length of shoreline) in a systematic manner.

We then allocated these 1-hectare bird territories – and associated density estimates – to 100 m-long segments of oiled shoreline. Thus, the territories covered the entire length of oiled shoreline, with no overlap between adjacent territories. We assumed that birds with territories that included oiled marsh shorelines – even if oil did not cover the entire 1-hectare territory – would potentially have been exposed to oil. Given that marsh birds use marsh edges disproportionately more than interior marsh areas within their territories or home ranges (e.g., Lewis and Garrison, 1983), this is a reasonable assumption.

The Trustees employed two alternative approaches to estimate shoreline oiling (DWH Trustees, 2015, Section 4.6). One approach projected shoreline observations of oiling from the shoreline assessment and clean-up technique (SCAT) onto a 2008 shoreline layer; the second approach allocated shoreline observations of oiling onto a higher resolution shoreline layer from 2010 (Wobus et al., 2015). In general, the shoreline lengths derived from the more complex 2010 shoreline layer exceeded that of the 2008 layer and consequently resulted in somewhat larger estimates of the extent of oiled shoreline.

For our analysis, we employed the shoreline lengths determined using the high resolution National Wetlands Inventory/U.S. Geological Survey (NWI/USGS) 2010 shoreline dataset, as described by Wobus et al. (2015). We also used the NWI/USGS dataset to assign the oiled shoreline to the different marsh habitats contained in that dataset. However, given that bird density data were only available for *Spartina* and *Phragmites* habitats, we restricted our analyses to mainland herbaceous *Spartina* marsh and *Phragmites* habitats. We estimated the number of birds present for two scenarios: (1) in marsh with any oiling (i.e., very light, light, moderate, heavily oiled); and (2) for heavily oiled only. Across Breton Sound, the Mississippi River Delta, Barataria, Terrebonne, and Vermilion basins, more than 1,000 km of marsh shorelines were oiled, of which more than 300 km were heavily oiled (Table 2).

Table 2. Estimated lengths of oiled shoreline based on maximum SCAT categories.

Shoreline lengths were allocated to specific habitat types using the 2010 NWI shoreline (Wobus et al., 2015).

Basin (east to west)	Oiled shoreline (km)			
	Mainland herbaceous marsh		<i>Phragmites</i> marsh	
	Heavily oiled	Oiled	Heavily oiled	Oiled
Breton Sound	0.4	36.4	0	0
Mississippi River Delta	0.7	4.5	68.3	167.1
Barataria	225.3	502.9	0	0
Terrebonne	63.1	335.7	0	0
Vermilion	0.2	6.7	0	0
Total	289.7	886.2	68.3	167.1

Finally, we multiplied habitat-specific densities for the four exemplar species reported by Conroy (2013) by the oiled shoreline lengths for each habitat type to estimate the total number of birds present in each habitat type. That is, we multiplied each bird species' density for *Spartina* marshes in Louisiana by the oiled shoreline lengths estimated for mainland herbaceous *Spartina* marshes, and we multiplied each bird species' density for *Phragmites* marsh in Louisiana by oiled shoreline lengths estimated for *Phragmites* marsh, and reported the values by basin.

4. Results: Estimated Potential for Marsh Bird Exposure

Based on the methods described above, we estimated that a total of approximately 56,000 individuals from these four bird species were present and therefore potentially exposed to *Deepwater Horizon* oil in oiled marsh habitats in Louisiana. Of these, 19,000 individuals were potentially present and therefore potentially exposed in marsh areas that were heavily oiled (Table 3).

Table 3. Estimated number of birds present in oiled interior mainland herbaceous and *Phragmites* marsh habitats in Louisiana

Species	Estimated exposures (# individuals)	
	Heavily oiled marsh only	All oiled marsh
Seaside Sparrow	10,279	31,150
Clapper Rail	4,567	13,844
Least Bittern	769	1,961
Red-winged Blackbird	3,067	8,693
Total	18,682	55,648

Barataria Bay had the highest number of potentially exposed marsh birds, followed by Terrebonne Bay and the Mississippi River Delta (Figure 1). This is because of the combination of higher-density estimates for birds in mainland herbaceous, *Spartina*-dominated habitats (Table 1) and the spatial distribution of oiled shoreline (Table 2). All estimated exposures in *Phragmites* habitats were calculated in the Mississippi River Delta; marsh habitats in this region are dominated by *Phragmites*, and they contain the majority of this habitat type state-wide.

Although we do not have direct observations of the extent of oil exposures associated with marsh oiling, it is realistic to assume that some proportion of the potentially exposed birds would have been exposed to *Deepwater Horizon* oil in marsh areas that were oiled, considering the marsh-dependent lifestyles of the exemplar species (e.g., their reliance on marsh vegetation for foraging, evading predators, mating, nesting, rearing young). Specifically, because heavily oiled areas had extensive oiling on the soil, oil coating the vegetation, and oil contaminating prey, birds that were present in these habitats would have been exposed via multiple pathways, and exposures would likely have been more severe and frequent than those in less oiled habitats. For example, birds would have come into direct contact with oiled vegetation through walking, perching, foraging, hiding from predators, etc.; and would have ingested oil when preening oil from feathers, eating contaminated prey, and unintentionally ingesting soil or sediment while feeding. Even in more lightly oiled habitats, these exposure pathways would have been present, although the probability and degree of exposure would likely have been lower than in heavily oiled areas.

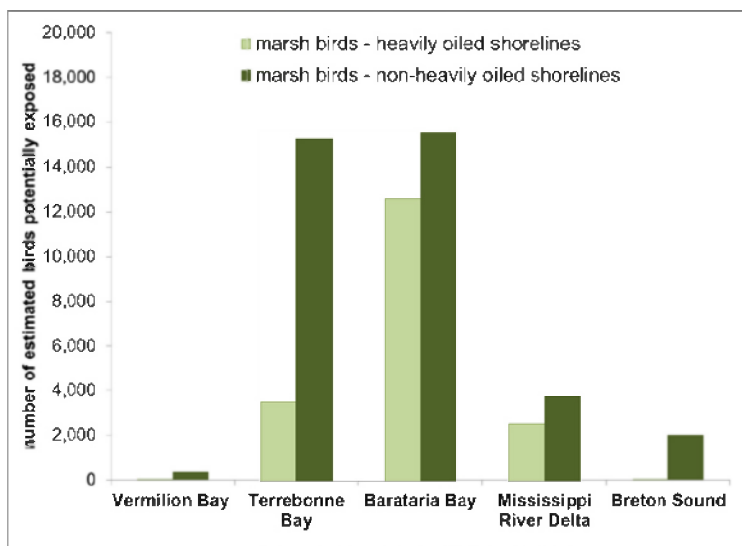


Figure 1. Number of estimated marsh birds exposed to *Deepwater Horizon* oil in five Louisiana coastal basins (oriented from west to east). Estimates were calculated using shorelines in all non-heavily oiled SCAT categories (dark green bars), and estimates were calculated using only heavily oiled shorelines (light green bars). Oiled shorelines in mainland herbaceous *Spartina* marsh and *Phragmites* marsh habitats were used in these calculations.

5. Discussion

5.1 Other Sources of Information Indicate that Birds Were Injured in Marsh Habitats

We estimated that approximately 56,000 birds of the four representative species were present in oiled marsh habitats. However, we did not quantify the degree and extent of injury. The actual

proportion of the birds present that came into contact with oil, and the extent of oil exposure, are uncertain because they were never measured due to difficulties sampling in dense marsh habitats (IEc, 2015). Consequently, quantification of the ultimate fate of oiled birds was not undertaken. However, some proportion of the potentially exposed birds were, in fact, exposed to oil. Further, it is highly likely that some proportion of those oiled birds were injured. This conclusion is supported by other sources of data that are described below.

During the bird carcass surveys performed by the Trustees (IEc, 2015), nearly 150 carcasses and live-impaired birds from the four representative species used in our analysis were recovered from marsh edges. As described in IEc (2015), there are many challenges to detecting small bird carcasses in these habitats. Marsh birds, particularly the obligate marsh bird species (e.g., Seaside Sparrows, Clapper Rails), are difficult to monitor under natural conditions. For example, searcher efficiency (i.e., the probability that a searcher will see an animal or carcass that is present) and carcass persistence (i.e., the amount of time that a carcass will remain available for detection on a shoreline) were lower along marsh edges than along beaches (USFWS, 2015a, 2015b). Furthermore, some debilitated marsh birds would likely have retreated into marsh vegetation to avoid detection by predators, and therefore would be virtually undetectable to observers. In addition to the above factors, many species of marsh birds, such as the exemplar species used in our analyses, might have died inside their marsh habitat territories rather than right at the marsh edge or in the water. These survey searches were limited to marsh edges and were not designed to quantify the exposures of interior marsh birds, resulting in an extremely low probability that marsh birds would be detected by these survey efforts. Because of these limitations, the actual number of dead marsh birds would have been considerably higher than the quantification in the PDARP.

In a field study conducted in 2012–2013 in Plaquemines Parish, Louisiana, Bergeon Burns et al. (2014) observed decreased reproductive output and nest success for Seaside Sparrows in oiled marsh habitats compared to unoiled habitats. Specifically, Seaside Sparrow nests in oiled areas were 5 to 10 times less likely to successfully fledge than nests in unoiled areas (Bergeon Burns et al., 2014).

Finally, both internal and external exposure of birds to *Deepwater Horizon* oil caused a suite of adverse effects. These adverse effects included feather damage and loss of function, resulting in increased energy expenditure; organ damage and physiological and hematological derangements; and mortality (Bursian et al., 2015a; 2015b; Dorr et al., 2015; Maggini et al., 2015; Pristos et al., 2015). These documented effects indicate that even infrequent and seemingly less-severe exposure to oil could be injurious to birds.

In addition to marsh-obligate bird species, several other avian guilds regularly use marsh habitats for foraging (e.g., many wading birds and shorebirds). These species would have been exposed to oil while foraging in oiled marsh areas, but some would have moved out of marsh habitats on

a daily basis to roost in other areas, such as forested wetlands and shrub-scrub habitats and were therefore not quantified in the pDARP.

5.2 Potential Sources of Bias in Calculations

Our approach included assumptions that could result in our calculated values being underestimated, as well as assumptions that could lead to our calculated values to overestimate the total number of potentially oiled birds. Additional studies could be undertaken to further reduce any uncertainties identified at this time.

Conservative assumptions and methods that likely would result in underestimating the actual numbers of birds potentially exposed in oiled habitats include the following:

- ▶ Although we estimated oiled shoreline lengths for other marsh habitat types (e.g., back-barrier marsh, mangroves), we restricted our analyses to the specific habitat types within Louisiana in which density estimates for the four exemplar species were reported as part of the *Deepwater Horizon* NRDA (Conroy, 2013). Therefore, birds occupying these other habitat types were not included in our analysis.
- ▶ Our analysis focused on four representative species. There are numerous other species that would likely have been exposed to oil in similar habitats, but they were not included in our analysis because density data similar to those reported by Conroy (2013) were unavailable.
- ▶ We applied the density estimates reported by Conroy (2013) only to areas adjacent to marsh edges, and not farther into interior marsh habitats. Some birds whose home ranges include, but are not restricted to, this marsh edge area would likely have also been exposed to oil; however, our simplified approach did not account for these birds.
- ▶ Surveys were conducted in June and July, which was likely after the period when some species are most likely to call and be recorded (e.g., April through June). This difference in timing of peak calling and when surveys were conducted might have underestimated densities for some species.
- ▶ Furthermore, these density estimates, and our estimates of birds potentially exposed to oil, do not account for newly fledged young of year birds that are accompanying adults but not vocalizing to be detected in call back surveys.

Assumptions in our calculations that could lead to our numbers being overestimates include the following:

- ▶ We assumed that bird territories were continuous along the oiled shoreline areas. Although this assumption may be reasonable given that average bird densities were employed in our calculations, spatial discontinuities in habitat occupancy would have a downward influence on the calculated number of potentially exposed birds.
- ▶ We assumed that a bird occupying a 100 m x 100 m territory could potentially have been exposed to oil along the marsh edge. Oiling of marshes generally occurred along a 2–8 meter edge (Wobus et al., 2015). Therefore, a small fraction of the total territory would likely have been oiled. Because of the disproportionate use of the marsh edge by the exemplar species, particularly for foraging, we believe our assumption to be reasonable. However, it is indeed possible that birds in the interior marsh would not have contacted the oiled marsh edge, or might have moved to another unoiled location when using the marsh edge. Consequently, this factor could result in our calculations being overestimates of potential exposure.

Another source of scientific uncertainty in our analysis that has an unknown influence on our calculations is the following:

- ▶ We assumed that the species- and habitat-specific density estimates reported by Conroy (2013) were uniform in time and space wherever a given species-habitat combination occurred in Louisiana. If density estimates varied during 2010, particularly as marsh areas were progressively oiled, this would have affected the number of birds exposed to oil.

5.3 Summary of Conclusions

Available information on average abundance of four representative species of Louisiana coastal marsh birds, together with information on the linear extent of oiling along Louisiana mainland herbaceous marsh edge habitat, enabled us to estimate the number of marsh birds of these representative species that were potentially exposed to *Deepwater Horizon* oil. Using this approach, we estimated that approximately 19,000 birds of the four representative species were potentially exposed in heavily oiled shorelines, and that another 35,000 individuals of these four species were potentially exposed in less heavily oiled marsh habitats.

For purposes of this analysis we did not quantify the degree and extent of injury. The actual proportion of the birds present that came into contact with oil is uncertain because of difficulties sampling in dense marsh habitats (IEC, 2015). Similarly, the degree to which birds were oiled is uncertain. Consequently, quantification of the ultimate fate of oiled birds was not undertaken at

this time. However, some proportion of the potentially exposed birds were, in fact, exposed to oil. Further, some proportion of those oiled birds were injured. As described above, other sources of information support the conclusion that an unquantified number of marsh birds were injured by the oil spill.

Although this specific injury is largely unquantified at this time, habitat restoration in complex coastal marsh habitats such as those that were oiled would be effective approaches to restore to these marsh-dependent species.

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